

## **APPENDIX B**

### **Forest Road Sediment Assessment Method (FROSAM)**

## Introduction

Section 303 of the Clean Water Act requires the identification of all impaired waterbodies in the United States. Once identified, the Clean Water Act further requires the establishment of a maximum pollutant load that can be assimilated by a given impaired waterbody and the implementation of an explicit plan to keep total pollutant loads below that maximum. The water quality improvement plans that are developed to meet these requirements are known as TMDLs (Total Maximum Daily Load).

The development of TMDLs for waterbodies impaired by siltation has become one of the major challenges for states that have substantial numbers of watersheds with agriculture and timber harvest as the dominant land uses. The challenge has two facets: first, an accurate assessment of the existing sources of siltation must be conducted and second, an accurate measure of any improvements must be made.

In most of the managed forested watersheds in the Western United States, forest roads are frequently one of the largest sources of non-point source pollution. The following discussion presents a practical approach for quantifying sediment load from forest roads as well as predicting and measuring improvements made during TMDL implementation.

The assessment method presented here is a refinement of the methods developed by the Washington Forest Practices Board, which is essentially an accounting procedure involving field observations of erosion and sediment delivery to streams. Streams are defined as any drainage depression containing a defined bed and banks extending continuously below the drainage site. Flow regime can be ephemeral, intermittent, or perennial. Therefore, erosion that is delivered to a drainage feature known to be discontinuous below (i.e. the flow goes subsurface and does not deliver to fish-bearing waters) should not be counted into the sediment load calculation.

## Methods

### Step 1: Measure Source Area

The source area for sediment load quantification encompasses all areas of road tread, ditches, cut slope, and fill slope from which water could flow to a stream. As an example in determining sediment load, suppose water flow over a road tread and cut slope is diverted by a drain-dip 100 feet from a stream crossing, and then passes into a heavily vegetated, flat area that precludes overland flow from reaching the stream. The area uphill of the drain-dip would not be counted into the sediment load to the stream, since the drain-dip serves to isolate it from the stream.

The length (longitudinally along the road) and width (across the road prism) of the tread, cut slope and fill slope are measured to derive the total areal extent (acres) of source area. If the cut and fill slopes vary significantly in width along a reach of road, the observer must estimate an average width of those features.

## Step 2: Apply Modifying Factors

Several modifying factors which are described below and summarized in **Table B-1** are applied to the measurement of actual eroding surface area. These are applied as average factors over each individual eroding area.

### Cover Factor

The cover factor is the percent of non-erodible cover on each of three road features: tread, cut slope, and fill slope. Cover percent translates into the modifying factors shown in **Table B-2**.

### Gravel Factor

The gravel factor accounts for reduced erosion from roads that have gravel applications. With a gravel lift of 2 to 6 inches in depth, the factor is 0.50. With a gravel lift of greater than 6 inches, the factor is 0.20.

### TrafficFactor

The traffic multiplier accounts for the fact that roads receiving heavy truck traffic have higher erosion rates. This factor ranges from 1 to 50, as shown in **Table B-3**. The value assigned depends on the use that the road experiences, with heavier traffic volume resulting in a greater multiplier.

### Percent Delivery

The determination of the percent of eroded fine sediment delivered to a stream is perhaps the most challenging part of this assessment methodology. This factor must take into account the observer's sense of sediment delivery over time and, without an accurate way to characterize historical or potential future sedimentation, it becomes a matter of professional judgment.

Another difficulty in establishing sediment delivery is the potential for "double mitigation". For example, the calculated amount of sediment generated at a given location would be overly reduced if the gravel factor was applied while the percent delivery was simultaneously reduced due to the lack of sediment generation. This would result in a double mitigation. The amount of fine sediment *generated* and the amount of fine sediment *delivered* are two different factors. To avoid this pitfall, "delivery" is considered as the *potential* for sediment to be carried to a stream once it is eroded. If there is no sediment being eroded, the lack of erosion is accounted for with the modifying factors of cover, gravel, etc.

**Table B-4** describes the categories of sediment delivery to streams. These can be adjusted based on the experience and judgment of the observer.

## Step 3: Calculate Road Sediment Load

To calculate the volume of sediment contribution from each road location, the following steps should be applied:

1. Assign a base (natural) erosion rate from roads in tons/acre/year. This can be derived from a combination of published values and professional knowledge of the soils in the watershed.
2. Calculate the area of erosion (length times width) for the tread, cut and fill slopes, and convert it to acres.
3. Apply each modifying factor: cover, gravel, traffic, and percent delivery.
4. Multiply all of these together to derive the sediment volume from each of these road features (road tread, cut slope and fill slope) individually.
5. Sum these three values for the total delivery for that location, which will yield a figure in tons of sediment per year.

Location totals thus derived can be summed for the entire watershed to arrive at a total fine sediment contribution from roads.

**Table B-1. Factors Applied in Forest Road Surface Sediment Assessment.**

<b>Factor</b>	<b>Definition</b>
Cover	Percent of non-soil cover.
Gravel	A categorical factor accounting for mitigating that results in gravel road surfacing.
Traffic	Factor accounting for higher erosion from higher traffic roads.
Delivery	Percent of displaced fine sediment which is delivered into a waterbody.

**Table B-2. Factor for Percent Cover Values.**

<b>Cover Percent</b>	<b>Factor</b>
>80%	0.18
50%	0.37
30%	0.53
20%	0.63
10%	0.77
0%	1.00

**Table B-3. Traffic Factors.**

<b>Traffic Use/Road</b>	<b>Annual Precipitation</b>
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<b>Category</b>	<b>&lt;1200 mm</b>	<b>1200 mm-3000 mm</b>
Heavy Traffic--active mainline	20	50
Moderate Traffic--active secondary	2	4
Light Traffic--not active	1	1

**Table B-4. Categories of Sediment Delivery to Streams.**

<b>Percent Category</b>	<b>Description</b>
100%	Chronic direct delivery under most erosional scenarios.
75%	Direct delivery evident but not chronic; effective buffer (provided by distance, gentle topography, or vegetation) during low intensity erosional events.
50%	Direct sediment delivery, but minor amounts or older events.
25%	Direct delivery unlikely except in moderate to major erosional events.
5%	Effective buffer, but proximity of road to stream makes 5% necessary.



Ninemile TMDL - Existing Road Sediment Sources																																
Location Number	Drainage	TREAD				CUTSLOPE				FILLSLOPE																						
		Tread Length (ft)	Tread Width (ft)	Acres of Tread	Base Erosion Rate (tons/ac/yr)	Gravel Factor	Traffic Factor	Percent Cover	Cover Factor	Percent Delivery	Delivery Factor	Cutslope Length (ft)	Avg. Cutslope Width (ft)	Acres of Cutslope	Base Erosion Rate (tons/ac/yr)	Percent Cover	Cover Factor	Percent Delivery	Delivery Factor	Cutslope Length (ft)	Fillslope Width (ft)	Avg. Fillslope	Acres of Fillslope	Base Erosion Rate (tons/ac/yr)	Percent Cover	Cover Factor	Percent Delivery	Delivery Factor	Fillslope Delivery (tons/yr)	Location Total Sediment (tons/yr)	Comments	
1	Ninemile	325	20	0.149219	30	1	2	10	0.77	50	0.5	3.4469697	270	16	0.0991736	30	75	0.21	50	0.5	0.3123669	75	6	0.0103306	30	90	0.12	90	0.9	0.033471074	3.793	
2	Ninemile	370	20	0.169881	30	1	2	10	0.77	75	0.75	5.8963636	280	28	0.1799816	30	50	0.37	65	0.65	1.29856749	110	8	0.0151515	30	90	0.15	90	0.9	0.0613636	7.246	
3	Ninemile	0	0	0	30	1	1	0	0	0	0	0	0	0	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000	No crossing; no channel		
4	Ninemile	1430	20	0.656566	30	1	2	10	0.77	80	0.8	24.2666667	770	12	0.2121212	30	65	0.27	80	0.8	1.37454545	104	8	0.0143251	30	90	0.15	90	0.9	0.059016529	25.699	
5	Ninemile	0	0	0	30	1	1	0	0	0	0	0	0	0	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000	Non-contributing. Road obliterated, recontoured and revegetated.		
6	Ninemile	0	0	0	30	1	1	0	0	0	0	0	0	0	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000	Non-contributing. Road obliterated, recontoured and revegetated.		
7	Ninemile	0	0	0	30	1	1	0	0	0	0	0	0	0	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000	Non-contributing. Road obliterated, recontoured and revegetated.		
8	Ninemile	200	15	0.068871	30	1	1	30	0.53	20	0.2	0.21900826	0	0	0	30	0	0	0	0	0	55	6	0.0075758	30	100	0.1	90	0.9	0.020454545	0.239	
9	Ninemile	630	15	0.216942	30	1	1	40	0.45	55	0.55	1.61079545	120	10	0.0275482	30	90	0.15	50	0.5	0.06198347	65	12	0.0179063	30	95	0.12	95	0.95	0.061239669	1.734	
10	Ninemile	230	22	0.116162	30	1	2	5	0.9	25	0.25	1.56818182	210	60	0.2892562	30	45	0.41	25	0.25	0.88946281	90	40	0.0826446	30	90	0.15	100	1	0.371900826	2.830	#10-11 has a perched outlet - fish barrier
11	Ninemile	320	24	0.176309	30	1	2	5	0.9	25	0.25	2.38016529	240	16	0.081543	30	75	0.21	20	0.2	0.11107438	90	8	0.0165289	30	90	0.15	90	0.9	0.066942149	2.559	#10-11 has a perched outlet - fish barrier
12	Ninemile	0	0	0	30	1	1	0	0	0	0	0	0	0	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000	Non-contributing. Road obliterated, recontoured and revegetated.		
13	Ninemile	0	0	0	30	1	2	0	0	0	0	0	0	0	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000	No crossing; no channel		
14	Ninemile	0	0	0	30	1	1	0	0	0	0	0	0	0	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000	Non-contributing. Abandoned, overgrown road, dense vegetation.		
15	Ninemile	0	0	0	30	1	2	0	0	0	0	0	0	0	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000	No crossing; No channel or pipe		
16	Ninemile	210	18	0.086777	30	1	1	20	0.63	70	0.7	1.14805785	195	10	0.0447658	30	90	0.15	60	0.6	0.12086777	70	25	0.0401745	30	80	0.18	95	0.95	0.020695041	1.475	
17	Ninemile	0	0	0	30	1	2	0	0	0	0	0	0	0	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000	No crossing; no channel		
18	Ninemile	0	0	0	30	1	1	0	0	0	0	0	0	0	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000	Non-contributing. Abandoned, overgrown road, dense vegetation.		
19	Ninemile	220	18	0.090909	30	1	1	10	0.77	40	0.4	0.84	180	12	0.0495868	30	70	0.23	40	0.4	0.1368595	60	16	0.0220366	30	90	0.15	70	0.7	0.069421488	1.046	
20	Ninemile	0	0	0	30	1	1	0	0	0	0	0	0	0	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000	Non-contributing. Overgrown, abandoned. Kelly hump at @29.		
21	Ninemile	0	0	0	30	1	1	0	0	0	0	0	0	0	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000	Non-contributing. Dense mature vegetation on tread, abandoned.		
22	Ninemile	450	20	0.206612	30	1	2	5	0.9	45	0.45	5.02066116	410	14	0.1317723	30	50	0.37	35	0.35	0.51193526	80	15	0.0275482	30	95	0.12	90	0.9	0.089256198	5.622	
23	Ninemile	440	22	0.222222	30	1	2	5	0.9	50	0.5	6	370	18	0.1528926	30	45	0.41	15	0.15	0.28208678	75	8	0.0137741	30	90	0.15	95	0.95	0.056884298	6.341	
24	Ninemile	0	0	0	30	1	2	0	0	0	0	0	0	0	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000	Non-contributing. Abandoned, overgrown road, no pip		
25	Ninemile	1320	16	0.484848	30	1	2	5	0.9	45	0.45	11.7818182	1190	8	0.2185491	30	90	0.15	40	0.4	0.39338843	40	6	0.0055096	30	90	0.15	90	0.9	0.02231405	12.198	
26	Ninemile	1380	22	0.69697	30	1	1	5	0.9	45	0.45	8.46818182	1270	30	0.8746556	3																





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331	Ninemile	125	23	0.066001	30	1	2	10	0.77	70	0.7	2,1344637	60	2	0.0027548	30	40	0.45	40	0.4	0.01487603	90	8	0.0165289	30	90	0.15	90	0.9	0.066942149	2,216		
332	Ninemile	0	0	0	30	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000 Non-contributing. Crossing is no longer in use (just cows);			
333	Ninemile	885	32	0.650138	30	0.5	2	20	0.63	55	0.55	6,75818182	0	0	0	0	30	0	0	0	0	0	0	95	8	0.0130854	30	80	0.18	90	0.9	0.063595041	6,822 Combined (2) pipes
334	Ninemile	0	0	0	30	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000 No channel			
335	Ninemile	0	0	0	30	1	1	0	0	0	0	0	0	0	0	0	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000 No channel		
336	Ninemile	0	0	0	30	1	1	0	0	0	0	0	0	0	0	0	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000 No channel		
337	Ninemile	0	0	0	30	1	1	0	0	0	0	0	0	0	0	0	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000 No channel		
338	Ninemile	150	16	0.050996	30	1	1	100	0.1	50	0.5	0.08264463	110	4	0.010101	30	75	0.21	50	0.5	0.03181818	50	4	0.0045914	30	90	0.15	90	0.9	0.018595041	0.133 No pipe.		
339	Ninemile	610	20	0.280073	30	1	2	10	0.77	50	0.5	6,469696937	600	12	0.1652693	30	90	0.15	50	0.5	0.037190083	90	14	0.0289256	30	100	0.1	100	1	0.08677686	6,928		
340	Ninemile	0	0	0	30	1	1	0	0	0	0	0	0	0	0	0	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000 Non-contributing due to dense vegetation		
341	Ninemile	390	24	0.214876	30	1	1	70	0.23	45	0.45	0.66719008	320	8	0.0587695	30	80	0.18	40	0.4	0.12694215	70	10	0.0160698	30	100	0.1	80	0.8	0.038567493	0.833		
342	Ninemile	0	0	0	30	1	1	0	0	0	0	0	0	0	0	0	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000 no channe		
343	Ninemile	0	0	0	30	1	1	0	0	0	0	0	0	0	0	0	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000 private and gated, not visite		
344	Ninemile	50	22	0.025253	30	1	2	20	0.63	10	0.1	0.09545455	40	24	0.0220386	30	50	0.37	10	0.1	0.02446281	40	8	0.0055098	30	100	0.1	90	0.9	0.014876033	0.135		
345	Ninemile	460	16	0.168962	30	0.5	1	50	0.37	25	0.25	0	0	0	0	0	120	14	0.0385675	30	95	0.12	75	0.75	0	0	0	0	0.000 private				
346	Ninemile	750	12	0.206612	30	1	2	10	0.77	75	0.75	7,15909091	0	0	0	0	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000 Non-contributing due to dense vegetation on road trea		
347	Ninemile	0	0	0	30	1	2	0	0	0	0	0	0	0	0	0	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000 Non-contributing due to dense vegetation on road trea		
348	Ninemile	250	22	0.126263	30	1	2	10	0.77	45	0.45	2,625	0	0	0	0	30	0	0	0	0	0	60	4	0.0055098	30	100	0.1	90	0.9	0.014876033	2,640	
349	Ninemile	0	0	0	30	1	1	0	0	0	0	0	0	0	0	0	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000 no channe		
350	Ninemile	0	0	0	30	1	1	0	0	0	0	0	0	0	0	0	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000 Non channel		
351	Ninemile	0	0	0	30	1	1	0	0	0	0	0	0	0	0	0	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000 Non-contributing due to dense vegetation		
352	Ninemile	610	22	0.308081	30	0.5	1	25	0.58	80	0.8	2,14424242	195	6	0.0268595	30	95	0.12	50	0.5	0.04834711	110	8	0.020202	30	95	0.12	90	0.9	0.065454545	2,259 private		
353	Ninemile	0	0	0	30	1	1	0	0	0	0	0	0	0	0	0	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000 Non-contributing due to dense vegetation		
354	Ninemile	1980	20	0.989091	30	1	2	10	0.77	50	0.5	21	160	20	0.0734619	30	75	0.21	45	0.45	0.20826446	85	8	0.0156107	30	100	0.1	80	0.8	0.037465565	21,246		
355	Ninemile	330	16	0.121712	30	0.5	1	20	0.63	50	0.5	0.572272727	110	7	0.0176768	30	50	0.5	25	0.25	0.08628788	90	10	0.0206612	30	90	0.15	85	0.85	0.079028926	0.718 private		
356	Ninemile	340	24	0.167528	30	0.5	1	20	0.63	70	0.7	1,23917355	0	0	0	0	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000 private		
357	Ninemile	540	22	0.272727	30	1																											







